REPORT RESUMES

ED 003 629 56

THE DEVELOPMENT AND EVALUATION OF A PROGRAMING TECHNIQUE FOR RELATING FRAME DIFFICULTY TO THE ABILITY OF THE LEARNER.
FINAL REPORT, PART II, APPENDICES.
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REPORT NUMBER NDEA-VIIA-1029-2 PUB DATE 65
GRANT OEG-7-48-0070-195
EDRS PRICE MF-$0.18 HC-$3.20 80P.

DESCRIPTORS- *PROGRAMED MATERIALS, PROGRAMED TEXTS, *CONCEPT TEACHING, *SET THEORY, *HEALTH EDUCATION, *BIOLOGY, PROGRAM EVALUATION, LEWISBURG, PENNSYLVANIA

SAMPLES OF THE EXPERIMENTAL MATERIALS USED IN THE BASIC STUDY, ED 003 628, WERE PRESENTED IN APPENDIXES FOR EACH OF THE FOUR EXPERIMENTS. AN EXISTING PROGRAM IN ELEMENTARY SET THEORY WAS MODIFIED IN EXPERIMENT ONE TO REDUCE THE UNITS OF INFORMATION PRESENTED IN EACH FRAME AND, IN A SECOND CASE, TO INCREASE THE NUMBER OF UNITS PER FRAME. SAMPLE PROGRAMED SECTIONS AND TESTS WERE PRESENTED. EXPERIMENT TWO MATERIALS INVOLVED SIX PROGRAMS WHICH WERE USED TO DETERMINE THE EFFECTS OF VARYING THE NUMBER OF ATTRIBUTES PRESENTED PER FRAME ON ACQUISITION IN THE ASSOCIATION STAGE OF LEARNING. EXPERIMENT THREE MATERIALS CONTAINED GENERAL BIOLOGY TEACHING FRAMES FOLLOWED BY PRACTICE ITEMS. MATERIALS USED IN EXPERIMENT FOUR INVOLVED FOUR DIFFERENT FORMS OF A PROGRAM ON THE ELEMENTARY CONCEPTS OF MATURATION AND GROWTH. (JM)

ED003629

A-1029-2

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PART II

APPENDICES

for

THE DEVELOPMENT AND EVALUATION OF A PROGRAMMING TECHNIQUE FOR RELATING FRAME DIFFICULTY TO THE ABILITY OF THE LEARNER

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Final Report: USOE, Title VII, Grant No. 7-48-0070-195

APPENDIX A

SAMPLES OF EXPERIMENTAL MATERIALS USED IN EXPERIMENT I

SECTION I

Q1. The set containing the numbers 1,2,3,4 can be written:

$\{1,2,3,4\}$

How can you write: The set containing the colors red, white, blue.

A1. $\{\text{red, white, blue}\}$

Q2. In the preceding example, we used the symbols $\{\ \}$ to mean the set containing. The set containing Mary, Jane, Bill can be written:

___Mary, Jane, Bill___ (Copy the names when you answer this

A2. $\{\text{Mary, Jane, Bill}\}$

Q3. The symbol, $\{\ \}$, meaning ____ ______ ______________, is called braces.

$\{\text{dog, cat, bird}\}$

In the set above, what is the symbol used? (Express the symbol and its name.)

A3. the set containing

$\{\ \}$, braces

Q4. The set containing the numbers 1,3,5,7 is written in symbols $\{1,3,5,7\}$ with each element listed.

List the following in short form: spring, summer, autumn

A4. {spring, summer, autumn}

Q5. When we list the elements of a set within braces, we are using the listing method. Which of the following uses the listing method?

(a) the set containing the fractions $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{5}$.

(b) $\left\{\frac{1}{2}, \frac{1}{3}, \frac{1}{5}\right\}$

A5. (b)

Q6. We can describe a set by saying: the set containing the numbers 1,3,5,7.

Write in words this set: $\{3,7,8,11\}$

A6. $\{3,7,8,11\}$ is the set containing the numbers 3, 7, 8 and 11.

Q7. {2,4,6,8}

You can describe the above set in words as the _____ containing the members __________.

Another way of describing this set is by describing the numbers in it, such as even numbers, odd numbers, multiples of 3, etc.

This set is made up of even numbers from 2 to 8 inclusive, therefore it is

"the _____ containing the _____ numbers from _____ to _____ inclusive".

Q7. set; 2,4,6,8

set; even; 2, 8

*Q8. {1,3,5,7}

Describe this set in words in two different ways.

A8. (1) The set containing the elements 1, 3, 5,7.

(2) The set containing the odd numbers from 1 to 7 inclusive.

Q9. When we describe a set we use the word "inclusive" to show that the two end numbers mentioned are elements of the set.

1. If we have the set of even numbers from 4 to 12 inclusive
   (a) Is 4 an element of the set?
   (b) Is 12 an element of the set?

(continued on next page)

Q9. (cont.)

(2) If we have the set of whole numbers from 3 to 15 which are evenly divisible by 3:
Is 15 an element of the set?

A9.

1. (a) yes
   (b) yes

2. no

Q10. Sometimes instead of mentioning all the elements or _______ of a set, we give the set a name.

For example, A = $\{2,4,6\}$

In words, we mean "A is the set containing the elements 2, 4, 6".

The set here is _____.

$\{\ \}$ means _____ _____ ______________

A10.

members
A
the set containing (capital letters of the alphabet are often used to designate sets)

Q11. A = $\{1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19\}$

As you can see from set A above, sometimes there are so many elements to a set that listing them would take too much time. The above set could be written:

A = $\{1,2,3,4\ldots\ldots19\}$

The dashes merely mean that the whole numbers from _____ to ______ have not been written but are still contained in set ____.

A11. 5 to 18

Q12. You have learned that the dashes represent the elements of the set between two numbers, which, as a matter of convenience, have been omitted.

Sometimes there is no last element in the set and the dashes show that the established pattern is to be followed without end, as in this set:

$\{2,4,6,8........\}$

Explain what the dashes mean in each of the following sets:

1. $\{5,10,15,20.....\}$
2. $\{1,2,3,4......10\}$

A12.

1. the dashes represent numbers which are evenly divisible by 5 from 20 on without end.
2. the dashes represent the whole numbers from 4 to 10.

Q13. Use the listing method and dashes to write the following sets:

(a) A is the set containing odd numbers from 1 to 29 inclusive.

(b) B is the set containing the whole numbers beginning with 10.

(c) C is the set containing multiples of 3 from 3 to 18 inclusive.

A13.

(a) A - $\{1,3,5......29\}$

(b) B - $\{10,11,12......\}$

(c) C - $\{3,6,9......18\}$

*Q14. Using the listing method and dashes: describe the set B containing the whole numbers 0 through 6000 inclusive.

A14. B - {0,1,2.......6000}

*Q15. The symbol { } means ______ ______ ________________.

A15. the set containing

Q16. {5,10,15,20,25}

You can use words to describe the above set in two ways:

(1) the ____ containing the whole numbers 5,10,15,20 and 25.

(2) the ____ containing the whole numbers from _____ to _______ inclusive which are evenly divisible by _____.

A16. (1) set

(2) set; 5; 25; 5

Q17. A - {2,4,6,8......24}

B - {2,4,6,8.......}

(a) You know the last element in set ______, but there is no last element in set ______.

(continued)

Q17. (cont.)

(b) The set of even numbers from 2 to 24 inclusive describes set ______; the set of even numbers beginning with 2 describes set ______.

A17.

(a) A; B

(b) A; B

Q18. Write each of the following using set notation:

(a) A is the set containing the whole numbers 1,2,7,8.

(b) B is the set containing all the whole numbers from 4 to 12 inclusive which are evenly divisible by 2.

A18.

(a) $A = \{1,2,7,8\}$

(b) $B = \{4,6,8,10,12\}$

Q19. $C = \{4,8,12,16,20,24\}$

The above set can be described in words as

(1) C is the ______ containing the ______ 4,8,12,16,20,24

and

(2) C is the ______ containing the numbers evenly divisible by ______ from 4 to ______ inclusive.

A19.

(1) set, elements

(2) set, 4, 24

Q20. $A = \{4,8,12,16.......\}$ (Notice there is no last element in A.)

____ is the set of whole numbers beginning with ____ which are evenly divisible by ______.

Write true or false for each statement below:

(a) $24 \notin A$

(b) $120 \notin A$

(c) $66 \in A$

(d) $310 \notin A$

A20. A; 4; 4

(a) false
(b) false
(c) false
(d) true

Q21. Write the following in symbols:

(a) F is the set of all whole numbers beginning with 35 that are divisible by 5.

(b) G is the set of numbers from 6 to 60 inclusive that are divisible by 3.

(c) Which of these sets has no last element?

A21.

(a) $F = \{35,40,45......\}$

(b) $G = \{6,9,12.....60\}$

(c) F

Q22. Write the set, P, of fractions from $\frac{1}{2}$ to $\frac{1}{128}$ (where the denominator is multiplied by 2) in short notation.

A22. $P = \left\{\frac{1}{2}, \frac{1}{4}, \frac{1}{8} \ldots\ldots \frac{1}{128}\right\}$

Notice here that the established pattern is multiplying the successive denominators by 2.

Q23. $K = \{3,6,9\ldots\ldots27\}$

(a) Is $12 \in K$?

(b) Is $18 \in K$?

(c) What do the dashes represent in set K?

A23.

(a) yes

(b) yes

(c) multiples of 3 from 12 to 24 inclusive,

or

between 9 and 27

(Notice the difference between the two definitions.)

Q24. Suppose we have the set: $X = \{4,8,12\ldots\ldots32\}$

What are the elements or members of the set X?

A24. The elements of the set are multiples of 4, from 4 to 32 inclusive.

Q25. M - {100,98,96.....16}

(a) Is 29 a member of this set?

(b) Is 36 a member of this set?

(c) Write 48 belongs to the set M in short notation. Is this a true statement?

A25.
(a) no
(b) yes
(c) $48 \in M$
(d) yes

Q26. Here are three descriptions of sets:

(a) A is the set of whole numbers starting with 0 and ending with 24 that are divisible by 8.

(b) B is the set of all whole numbers larger than 4 and smaller than 15 that are divisible by 17.

(c) C is the set of all numbers to which you can add 8 and get 8.

Which set, A, B or C, has one member? Which has four members? Which has no members?

A26.
C
A
B

SECTION I-B

Q1. The set containing the numbers 1,2,3,4 can be written {1,2,3,4} using the symbol, braces { } to mean "the set containing".

The set containing the colors red, green, yellow and blue could be written ________________.

What symbol did you use here? (Write the symbol and its name.)

A1. {red, green, yellow, blue}
{ } braces

Q2. When writing the set containing the numbers 1,3,5,7 in short form, {1,3,5,7} we list the elements and therefore call this notation the listing method.

Write the set containing the elements chair, table, lamp, using the listing method.

A2. {chair, table, lamp}

(Note: the braces { } show that the elements form a set and must always be used when writing a set.)

Q3. {2,3,4,5,6}

The _________ ___________ was used to write this set.

This set can be described in words in two different ways:
(1) The set containing the elements 2,3,4,5 and 6.
(2) The set of whole numbers from 2 to 6 inclusive.

Describe the following set in two ways:

{12,13,14,15}

A3. listing method
the set containing the elements 12,13,14,15.
the set of whole numbers from 12 to 15 inclusive.

Q4. When we describe a set we use the word "inclusive" to show that the two end terms mentioned are elements of the set. If "inclusive" is not used, the end terms are not members of the set.

1. If we have the set of even numbers from 4 to 12 inclusive:
   Is 4 an element of the set?
   Is 12 an element of the set?
2. If we have the set of whole numbers from 3 to 5 which are evenly divisible by 3:
   Is 15 an element of the set?

A4. 1. yes
yes
2. no

*Q5. Describe in words (2 ways) the following set:

{1,3,5,7}

A5. 1. The set containing the whole numbers or elements 1,3,5 and 7
2. The set of odd numbers from 1 to 7 inclusive.

Q6. Sometimes a set may contain many elements such as:

{1,2,3,4,5,6,7,8,9,10,11,12,13,14}

Since this takes too much time to write, we can express this in a shorter way by first showing a few of the elements in order to establish the pattern, and then using dashes in place of writing out all of the elements.

A (the set) - {1,2,3,4......14} meaning A is the set of whole numbers from 1 to 14 ______________. The dashes represent the numbers between 4 and 14 which are not written.

What do the dashes mean here?

B - {10,11,12.......30}

A6. inclusive
the numbers between 12 and 30 which are not written

Q7. Notice that we have been designating a set by a letter of the alphabet. This, too, is a shorter way of writing "the set". Write in words:

C - {5,10,15.......50}

(Be sure to give a description of the pattern of the set.)

A7. C is the set containing multiples of 5 from 5 to 50 inclusive

or

C is the set containing numbers from 5 to 50 inclusive which are evenly divisible by 5

*Q8. Using the listing method and dashes, describe the set B containing the whole numbers 0 through 6000 inclusive.

8 B = {0, 1, 2, 3, - - - - 6000}

*9 The symbol { } means ____ ____ ____.

---

9 the set containing

10 Write the following using set notation:

a) A is the set containing the whole numbers 1, 2, 7, 8
b) B is the set containing the whole numbers from 4 to 12 inclusive which are evenly divisible by 2.
c) What symbol did you use to mean "the set containing"?

---

10 A = {1, 2, 7, 8}

B = {4, 6, 8, 10, 12}

braces { }

11 C = {4, 8, 12, 16, 20, 24}

The set can be described in two ways:
1) C is the ____ containing the elements ____.
2) ____ is the ____ containing the numbers from ____ to ____ ____ which are evenly divisible by ____.

---

11 1) set 4, 8, 12, 16, 20, and 24.
2) C, set, 4, 24, inclusive, 4

12 D = {3, 6, 9, 12}

Use words to describe the above set in two ways.

---

12 D is the set containing the elements 3, 6, 9, and 12.

D is the set of numbers from 3 to 12 inclusive which are evenly divisible by 3.

Q27. 13 **If A = {1, 3, 4, 7, 9, 11, 12} , write true or false for each statement below:**

1) $7 \notin A$
2) $8 \notin A$
3) $10 \in A$
4) $14 \notin A$

- -

A27. 13

1) false
2) true
3) false
4) true

Q28. 14

$A = \{4, 8, 12, 16 - - - - - -\}$

Write true of false for each statement below.

1) $24 \notin A$
2) $120 \in A$
3) $45 \in A$

[redacted]

- -

A28. 14

1) false
2) true
3) false

[redacted]

Q29. 15 **Write the following in symbols (be sure to include enough elements to show the pattern of the set):**

(1) F is the set of all whole numbers beginning with 35 that are divisible by 5.
(2) G is the set of even numbers from 6 to 60 inclusive.

- -

A29. 15

(1) $F = \{35, 40, 45 - - - - - - \}$

(2) $G = \{6, 8, 10 - - - - - - - 60\}$

Q30. 16 **Write the set P of fractions from 1/2 to 1/128 inclusive where each successive denominator is multiplied by 2, in short notation.**

- -

A30. 16 $P = \{1/2, 1/4, 1/8 - - - - - - 1/128\}$

~~Q31~~. 17 What do the dashes represent in the set K = {3, 6, 9 - - - - -27} ?

- -

~~A31~~. 17 The dashes represent multiples of 3 from 12 to 24 inclusive (or the multiples of 3 between 9 and 27 - note the difference between these two definitions.)

~~Q32~~. 18 Suppose X = {4, 8, 12 - - - - 32}
Describe in words the elements or members of the set X.

- -

~~A32~~. 18 The elements of the set are multiples of 4 from 4 to 32 inclusive.

~~Q33~~. 19 M = {100, 98, 96 - - - - 16}

a) Is 29 a member of this set?
b) Is 36 a member of this set?
c) Using symbols write: 48 belongs to the set M.
Is this a true statement?

- -

~~A33~~. 19
a) no
b) yes
c) $48 \in M$
yes

~~Q34~~. 20 Suppose we have a set N which is a triangle with five sides. Since this situation is impossible, there are actually no members in the set N. When this happens, the set is empty and so we call it an empty or null set.

Consider the set of all people with three heads. How many elements are in the set?

- -

~~A34~~. 20 none

~~Q35~~. 21 Set B is the set of all trees which can walk. In mathematics we represent this like this: $B = \emptyset$. Notice that there are no elements in this set, not even 0.

What new symbol are you to learn here that means the empty set?

1-B

A35. 21 $\emptyset$

(Note: We write the elements of a set within braces $\{\}$. The empty set has no elements and therefore the symbol $\emptyset$ is never written $\{\emptyset\}$.)

Q36. 22 Suppose $A = \{1, 2, 3, 4, 5, 6\}$

$B = \{6, 4, 5, 3, 2, 1\}$

Does set B contain the same elements as set A? Does the order of the elements make any difference? When two sets contain exactly the same members the sets are equal. Are A and B equal sets or not? Why?

- -

A36. 22 yes
no
A and B are equal because they contain exactly the same elements.

Q37. 23 If two sets, C and D, contain exactly the same elements, they are ____. Using symbols this would be written $C = D$.

If two sets, E and F, do not contain exactly the same elements, they are unequal. Using symbols this would be written $E \neq F$.

Using symbols express the relationship between the following pairs of sets:
1) $L = \{1, 2, 3, 4, 5\}$ and $M = \{2, 3, 4, 5\}$

2) $N = \{5, 10, 15 - - - 25\}$ and $O = \{5, 10, 15, 20, 25\}$

- -

A37. 23 equal
1) $L \neq M$
2) $n. = O$

Q38. 24 Suppose we consider the set $A = \{2, 4, 6, 8, 10, 12, 14\}$

How many members does A have?

Here you can count the _____ of the set.

Now look at set $K = \{1, 3, 5, 7, 9- - -,-\}$.
Are you able to say exactly how many elements are in set K?

- -

A38. 24 7
elements or members
no

SECTIO

Q2-1 In this section you will learn:

(1) the meaning of { }.

(2) how to describe sets.

Q2-2 The set containing the numbers 1, 2, 3, 4, can be written:

{1, 2, 3, 4}

How can you write: The set containing the colors red, white, and blue?

A2-2 {red, white blue}

Q2-3 The set containing 1, 3, and 5, could be written: {1, 3, 5}. What symbol is used here instead of the words, "The set containir

---

A2-3 { }

Q2-4 The set containing the children Mary, Jane, Bill, and Henry can be written:

? Mary, Jane, Bill, Henry ?

(Copy the four names, when you answer this.)

A2-4 {Mary, Jane, Bill, Henry}

---

*Q2-5 The symbol { } means ___?___ ___?___ ___?___.

---

the set containing (or just set

Q2 Write the following by using the new symbol you learned: the set containing 6, 12, 15, 25, and 50.

A2-6 $\{6, 12, 15, 25, 50\}$

Q2-7 $\left\{\frac{3}{4}, \frac{2}{3}, \frac{1}{2}\right\}$

To describe the above set you could say: __?__ __?__ __?__ $\frac{3}{4}$, $\frac{2}{3}$, and $\frac{1}{2}$.

A2-7 the set containing

Q2-8 Write in words a description of $\{5, 8, 11\}$ by writing the phrase below completely and filling in the correct words as you do.

the set ___?___ the whole numbers _?_, _?_, and _?_

-8 the set containing the whole numbers 5, 8, and 11

-9 (a) The set containing the fractions $\frac{1}{2}$, $\frac{1}{3}$, and $\frac{1}{5}$.

(b) $\left\{\frac{1}{2}, \frac{1}{3}, \frac{1}{5}\right\}$

Both (a) and (b) describe the same set. The method which uses words of describing the set is illustrated by ___?___ (a,b) above; the listing method of describing the set is illustrated by ___?___ (a,b) above.

2-9 a ; b

2-10 (1) Use the listing method to describe the set containing the whole numbers 1, 2, and 3.

(2) Describe this set with words: $\{1, 2, 3\}$.

-1)

(1) $\{1, 2, 3\}$

(2) the set containing (the whole numbers) 1, 2, and 3

-11

(1) Use the listing method to write the set containing the whole numbers 8, 10, 12, 14, and 16.

(2) Describe in words: $\{1, 3, 5, 7\}$.

A2-11

(1) $\{8, 10, 12, 14, 16\}$

(2) the set containing (the whole numbers) 1, 3, 5, and 7

2-12

$\{2, 4, 6\ 8\}$

(a) the set containing the numbers 2, 4, 6, 8

(b) the set of even numbers from two to eight inclusive.

Both (a) and (b) describe the above set in two different ways by using words. Both (a) and (b) are correct.

Describe this set: $\{1, 3, 5, 7\}$ in the two ways illustrated by (a) and (b) above.

2-12

(1) the set containing the numbers 1, 3, 5, 7

(2) the set of odd numbers from one to seven inclusive.

(Inclusive merely means that the 1 and the 7 are included in the set being described.)

-13

$\{5, 10, 15, 20, 25\}$

You can use words to describe the above set in two ways:

(1) the set containing the whole numbers 5, 10, 15, 20, and 25

(2) the set containing the whole numbers from ___?___ to ___?___ inclusive which are evenly divisible by ___?___.

PRECEDING PAGE MISSING

2-17 (1) How would you write in words: P = {Mary, John, Henry} ?

(2) How would you write in words: N = {Lewisburg, Milton, Sunbury}

2-17 (1) P is the set (of people) containing Mary, John, and Henry.

(2) N is the set (of towns) containing Lewisburg, Milton, and Sunbury.

Q2-18 Write each of the following by using set notation (the listing method).

(1) A is the set containing the whole numbers 1, 2, 7 and 8.

(2) B is the set containing all the whole numbers from 4 to 12 inclusive which are equally divisible by 2.

(3) C is the set containing 10, 12, 19, 26, 55.

A2-18 (1) A = {1, 2, 7, 8}

(2) B = {4, 6, 8, 10, 12}

(3) C = {10, 12, 19, 26, 55}

Q2-19 A = {1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19}

As you can see from set A above, sometimes there are so many elements to a set that listing them would take too much time. The above set could be written: A = {1,2,3-----19}. The dashes merely mean that the whole numbers between __?__ to __?__ have not been written but are still contained in Set A.

2-19 4 ; 18

Q2-20 Write the following description by using dashes: B is the set of whole numbers from 0 to 6000 inclusive.

A2-20 B = {0, 1, 2 -----6000}

(The number of dashes you write is not important, just so you write at least three. Be sure to list at least three elements to show the pattern.)

Q2-21 $P = \{8, 12, 16, 20 ----- 80\}$

The above set would read: P is the set containing the whole numbers from ______ to ______ inclusive which are equally (d)_ _ _?_ _ _ _ _ by ___?___

A2-21 8 ; 80 ; divisible ; 4

Q2-22 $P = \{8, 12, 16, 20 ----- 80\}$

(a) P is the set containing the whole numbers from 8 to 80 inclusive which are equally divisible by 4.

(b) P is the set containing the whole numbers 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 52, 56, 60, 64, 68, 72, 76, and 80.

Which method above, (a) or (b) is probably the more sensible way to describe a "long" set such as set P?

A2-22 (a) You do not have to write all the members of the set.

---

*Q2-23 Describe each of the following sets.

(1) $C = \{10, 11, 12, 13, ---- 99\}$

(2) $D = \{3, 6, 9, 12, 15 ---- 396\}$

A2-23 (1) C is the set containing the whole numbers from 10 to 99 inclusive.

(2) D is the set containing the whole numbers from 3 to 396 inclusive which are equally divisible by 3.

Q2-24 How is the following expression written by using words only:

$6 \in$ set A

A2-24 Six is a member of set A

(Instead of "is a member of" you could have written: "is an element of" or "belongs to".)

Q2-25 Suppose A = $\{$a dog, a cat, a cow, a horse$\}$

(a) How could you write each of the following by using either $\in$ or $\notin$?

(1) A dog belongs to A.

(2) A horse is a member of A.

(3) A bird does not belong to A.

(b) Are the statements 1, 2, and 3 above true or false?

A2-25 (a) (1) A dog $\in$ A

(2) A horse $\in$ A

(3) A bird $\notin$ A

(b) true

Q2-26 You can see that you can pick out elements (or members) of sets to discuss them without extra writing or explanation if you use $\in$ or $\notin$.

Suppose P = $\{1, 2, 3, 4, 5, 6, 7, 8\}$

(1) How could you very briefly indicate (write) that the number 3 is a member of P ?

(2) 7 $\in$ P is read: ____________?____________ .

(3) How could you very briefly indicate that the number 10 is not an element of P ?

(4) 16 $\notin$ P is read: ____________?____________.

A2-26 (1) 3 $\in$ P

(2) Seven is a member of (belongs to; is an element of) set P.

(3) 10 $\notin$ P

(4) Sixteen is not a member of (does not belong to; is not an element of) set P.

ACHIEVEMENT TEST

1. Write the symbols for:

   a. is not an element of
   b. the complement of N
   c. is a subset of
   d. the universal set

2. In the set $A = \{a,b,c\}$ there are eight subsets. List all of them. Circle the improper subset. Underline the subset which is a subset of every set.

3. Explain in a few words:

   a. natural numbers
   b. empty or null set
   c. domain
   d. subset

4. Write the symbols for:

   a. multiplication
   b. is not a subset of
   c. intersection
   d. union

5. Explain in a few words:

   a. integer
   b. inequality
   c. the complement of a set
   d. union of A and B
   e. identity

6. Tell whether these pairs of sets are disjoint, intersecting, equal or one is a subset of the other.

   a. $A = \{2,4,6,8,10\}$ $B = \{2,8,10,16,4,12\}$
   b. $A = \{2,6,4,10,12,14\}$ $B = \{4,6,10,2,10\}$
   c. $A = \{2,4,6,8,10\}$ $B = \{12,14,16,18\}$
   d. $A = \{2,4,6,8,10\}$ $B = \{10,4,6,2,8\}$
   e. $A = \{2,4,6,8,10\}$ $B = \{6,10,2,4,8,12,6,2,10\}$

7. Write the symbols for:

   a. the set containing
   b. equal to
   c. is less than
   d. is a member of

8. Explain in a few words:

   a. counting numbers
   b. variable
   c. the intersection of A and B
   d. finite set

9. Consider these sets: $B = \{4, 8, 12 \ldots\ldots\}$
   $C = \{4, 8, 12 \ldots\ldots 60\}$

   Answer True or False:

   a. $20 \in B$
   b. $84 \in B$
   c. $18 \notin C$
   d. $20 \notin C$
   e. $60 \in B$
   f. $2 \in C$
   g. B is an infinite set
   h. $26 \in B$

10. Write the symbols for:

    a. is not greater than
    b. is less than or equal to
    c. is not equal to
    d. the continuation of a sequence of numbers

11. Suppose: $U = \{n \mid n + 2 \geq 2 \text{ and } n \in \text{whole numbers}\}$

    $A = \{n \mid n \leq 4 \text{ or } n \geq 8\}$
    $B = \{n \mid 3 \leq n < 7\}$
    $C = \{n \mid 3n \leq n + 12\}$

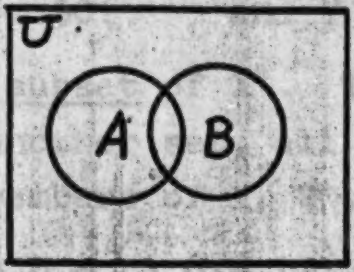
    a. List members of each of the sets above.
    b. Make a sketch on a number line of B and C.
    c. Find B'.
    d. Find $B \cup C$.
    e. Find $A \cap C$.
    f. Find $A \cap B \cap C$
    g. Find $A' \cap B \cap C$
    h. Find $C' \cap B$

12. Write the symbols for:

    a. is greater than
    b. is not less than
    c. the null or empty set
    d. is greater than or equal to

13. Using a copy of this model for each drawing, make Venn diagrams and shade the part to show the portions represented:

a. $A \cap B$
b. $A \cup B$
c. B'
d. $A' \cup B$
e. $A \cap B'$



D-Scale

PART I

Rate each of the following frames according to the following scale:
very easy, easy, average, hard, very hard.

****

1. Suppose $X = \{10,20,30.....50\}$ and $Y = \{20,30,40\}$

We can say that "Y is a subset of X". The word "subset" is just what it seems to be: it is another set, all of whose members are in the original set. All the members of Y, 20,30,40, can be found in X.

$A = \{3,6,9,12,15\}$ and $B = \{3,6,9,12\}$

B ________ (is, is not) a subset of A because all of the members in B ________ (are, are not) in A.

---

is

are

The above frame is in your opinion, ____ very easy, ____ easy, [✓ average], ____ hard, ____ very hard.

2. The expression $5 < n < 8$ means two things.

(1) If you begin reading the above with 5 and read right you would read: 5 is ________ than n.

(2) If you begin reading the above with n and read right you would read: n is ________ than 8.

Thus, we can read the whole expression in this way: 5 is ________ than n which is ________ than ________.

---

(1) less

(2) less

less; less; 8

The above frame is in your opinion, ____ very easy, ____ easy, [✓ average], ____ hard, ____ very hard.

3. When writing the set containing the numbers 1,3,5,7 in short form, $\{1,3,5,7\}$, we list the elements and therefore call this notation the listing method.

Write the set containing the elements chair, table, lamp, using the listing method.

{chair, table, lamp}.

(Note: the braces { } show that the elements form a set and must always be used when writing a set.)

The above frame is in your opinion, ____ very easy, ____ easy, ✓ average, ____ hard, ____ very hard.

---

4. B is the set of squares with nine sides each. Since set B cannot have any members, it is empty, so logically a set with no members is called an (e)__________ set.

---

empty

The above frame is in your opinion, ____ very easy, ____ easy, ✓ average, ____ hard, ____ very hard.

---

5. When we list the elements of a set within braces, we are using the listing method. Which of the following uses the listing method?

(a) the set containing the fractions $\frac{1}{2}, \frac{1}{3}, \frac{1}{5}$

(b) $\left\{\frac{1}{2}, \frac{1}{3}, \frac{1}{5}\right\}$

(b)

The above frame is in your opinion, ____ very easy, ____ easy, ✓ average, ____ hard, ____ very hard.

6. Suppose you are given the __________ set $U = \{10,20,30,40,50\}$ and $A = \{30,50\}$.

If A' is the set with all the members of the universe which are not in A, then:

A' = ____________ (copy "A' =" when you answer this.)

---

universal

$A' = \{10,20,40\}$

The above frame is in your opinion ____ very easy, ____ easy, __✓__ average, ____ hard, ____ very hard.

---

7. $U = \{5,6,7,8,9,10\}$

$B = \{5,7,8\}$

$B' = \{6,9,10\}$

(1) B' is the set containing the elements of U which ____________ (are, are not) in B.

(2) The ' is read: "prime"; B' is read: B ___________.

---

(1) are not

(2) prime

The above frame is in your opinion ____ very easy, ____ easy, __✓__ average, ____ hard, ____ very hard.

8. We sometimes want to combine two inequalities into one expression. For example, suppose $5 < n$ and also $n < 10$. We can combine these expressions by writing the n, which appears in both and then writing the correct symbols on either side to get: $5 < n < 10$.
Combine the following expressions:
(1) $4 < n$ and $n < 8$. (2) $10 < n$ and $20 > n$.
(3) $1 \leq n$ and $n \leq 3$.

---

(1) $4 < n < 8$ (2) $10 < n < 20$ (3) $1 \leq n \leq 3$

The above frame is in your opinion, ____ very easy, ____ easy, ____ average, [✓ hard], ____ very hard.

9. When these two conditions hold: Given set H, $J \subset H$, $J \neq H$ we call the subset, J, a proper subset of H.

(1) Tell which of the following are proper subsets:
Given set $B = \{l, m, n, o, p, q\}$
$A = \{l, m, n\}$ $C = \{p\}$ $D = \{l, m, n, o, p, q\}$ $E = \{4, p, q\}$

(2) What is the difference between a proper subset and an improper subset?

---

(1) A, C are proper subsets

(2) Both proper and improper subsets are subsets of a given set, but an improper subset is equal to the set itself and a proper subset is not equal to it.

The above frame is in your opinion, ____ very easy, ____ easy, ____ average, [✓ hard], ____ very hard.

10. You know that $x > 5$ means x is greater than 5; and $x = 5$ means x equals 5.
Sometimes the two expressions are combined into one like this: $x \geq 5$.
How would you combine the following:
(a) $n > 8$
$n = 8$
(b) $n > 12$
$n = 12$

(a) $n \geq 8$
(b) $n \geq 12$

The above frame is in your opinion, ____ very easy, ____ easy, [✓ average], ____ hard, ____ very hard.

11. Suppose $U = \{3,6,9,12\}$ $A = \{3,6\}$ $B = \{6,12\}$
Notice that 6 is the only element common to both sets A and B.
This is the intersection of A and B.
If: $C = \{1,2,3,4,5\}$
$D = \{3,5,7\}$
____ and ____ are common to C and D and therefore form the set called the __________ of C and D.

3, 5
intersection

The above frame is in your opinion, ____ very easy, ____ easy, [✓ average], ____ hard, ____ very hard.

12. The set of elements common to A and B is the set 12, and can be written: $A \cap B = \{12\}$.

(a) Using symbols write: The set of elements common to A and C is the set 15, 18, and 21.

(b) What symbol is used to mean the set of elements common to?

(a) $A \cap C = \{15,18,21\}$

(b) $\cap$

The above frame is in your opinion, ____ very easy, ____ easy, [✓ average], ____ hard, ____ very hard.

13. $\{n|n \geq 15\}$ would read: the set of numbers, n, such that the number is larger than or equal to fifteen. How would you write in symbols: the set of numbers such that the number is greater than or equal to four?

$\{n|n \geq 4\}$

The above frame is in your opinion, ____ very easy, ____ easy, ____ average, [✓ hard], ____ very hard.

14. It is not always so convenient to write in words "is a subset of", so we've invented a symbol for that.

B is a subset of A, can be written: $B \subset A$

C is a subset of K, can be written: $G \subset K$

1. N is a subset of M, can be written: ____________.

2. R is a subset of S, can be written: ____________.

$N \subset M$ $R \subset S$

The above frame is in your opinion, ____ very easy, ____ easy, ____ average, [✓ hard], ____ very hard.

15. Suppose we have a set N which is a triangle with five sides. Since this situation is impossible, there are actually no members in the set N. When this happens, the set is empty and so we call it an empty or null set.
Consider the set of all people with three heads. How many elements are in the set?

---

none

The above frame is in your opinion, ____ very easy, ____ easy, ____ average, [✓ hard], ____ very hard.

---

16. Suppose we have a set, but want to discuss just part of the set. Consider the set $A = \{1,2,3,4,7,8,9,10\}$. If we wish to discuss just the members 1, 2, 3, 4 we call this part of the set A a subset of A.
Thus $B = \{7,8,9,10\}$ is a ________ of the set ___.

---

subset, A

The above frame is in your opinion, ____ very easy, ____ easy, ____ average, [✓ hard], ____ very hard.

---

17. An expression written in set-builder notation such as
$A = \{n \mid n \in \text{whole numbers}\}$
would be read as: A is the set of numbers, n, such that the number is a whole number.
Similarly, we use these inequalities in set notation in the following way: $\{n \mid n \geq 15\}$, which reads: the set of numbers, n, such that the number is ______ than or ________ to 15.

---

greater (larger)
equal

The above frame is in your opinion, ____ very easy, ____ easy, [✓ average], ____ hard, ____ very hard.

18. Instead of using the words "is a subset of", a more convenient way to express this is the symbol $\subset$. If B is a subset of A, we write this: $B \subset A$. This means that all the elements of B are in set A.

Suppose B is not a subset of A. We would write it like this: $B \not\subset A$. In words, how is the symbol $\not\subset$ read?

---

is not a subset of

The above frame is in your opinion, ____ very easy, ____ easy, ✓ average, ____ hard, ____ very hard.

---

19. You know that $x > 5$ means x is greater than 5; and $x = 5$ means x equals 5 Sometimes the two expressions are combined into one like this: $n \geq 5$. This means n is greater than or equal to 5.

Use symbols to write the following:

(a) The number, n, is larger than or equal to 9.
(b) The number, n, is larger than 9.
(c) y is larger than or equal to z.

(a) $n \geq 9$ (b) $n > 9$ (c) $y \geq z$

The above frame is in your opinion, ____ very easy, ____ easy, ✓ average, ____ hard, ____ very hard.

---

20. There are two kinds of subsets. The first kind we shall consider is a proper subset.

Consider: $E = \{a,b,c,d\}$ $F = \{c,a\}$

To identify a set as a proper subset we must first see if it is a subset. Is $F \subset E$?
Then, if $F \neq E$, F is a proper subset of E.

F is a _______ subset of E because the following two conditions are true:
F ? E F ? E

---

yes, proper, $F \subset E$, $F \neq E$

The above frame is in your opinion, ____ very easy, ____ easy, ____ average, ✓ hard, ____ very hard.

PART II

The following frames are arranged in pairs - both frames present the same information. Read the frames carefully and select the frame, either A. or B., which you think is easier. Then write the letter in the space at the left.

* * * * * * * * * * * * * .

GROUP I

B________ (Write your answer, either A or B.)

A. We sometimes want to combine two inequalities into one expression. For example, suppose $5 < n$ and also $n < 10$. We can combine these expressions by writing the n, which appears in both and then writing the correct symbols on either side to get: $5 < n < 10$.
Combine the following expressions:
(1) $4 < n$ and $n < 8$. (2) $10 < n$ and $20 > n$.
(3) $1 \leq n$ and $n \leq 3$.

---

(1) $4 < n < 8$ (2) $10 < n < 20$ (3) $1 \leq n \leq 3$

B. The expression $5 < n < 8$ means two things.
(1) If you begin reading the above with 5 and read right you would read: 5 is ________ than n.
(2) If you begin reading the above with n and read right you would read: n is ________ than 8.
Thus, we can read the whole expression in this way: 5 is ________ than n which is ______ than ________.

---

(1) less
(2) less
less; less; 8

GROUP II

B (Write your answer, either A or B.)

A. B is the set of squares with nine sides each. Since set B cannot have any members, it is empty, so logically a set with no members is called an (e)________ set.

---

empty

B. Suppose we have a set N which is a triangle with five sides. Since this situation is impossible, there are actually no members in the set N. When this happens, the set is empty and so we call it an empty or null set.
Consider the set of all people with three heads. How many elements are in the set?

---

none

GROUP III

A (Write your answer, either A or B.)

A. When writing the set containing the numbers 1,3,5,7 in short form, $\{1,3,5,7\}$, we list the elements and therefore call this notation the listing method.
Write the set containing the elements chair, table, lamp, using the listing method.

---

chair, table, lamp

(Note: the braces $\{\}$ show that the elements form a set and must always be used when writing a set.)

B. When we list the elements of a set within braces, we are using the listing method. Which of the following uses the listing method?
(a) the set containing the fractions $\frac{1}{2}, \frac{1}{3}, \frac{1}{5}$.
(b) $\left\{\frac{1}{2}, \frac{1}{3}, \frac{1}{5}\right\}$

(b)

GROUP IV

____B____ (Write your answer, either A or B.)

A. $U = \{5,6,7,8,9,10\}$ $B = \{5,7,8\}$

$B' = \{6,9,10\}$

(1) B' is the set containing the elements of U which ________ (are, are not) in B.

(2) The ' is read: "prime"; B' is read: B ________.

---

(1) are not

(2) prime

B. Suppose you are given the ________ set $U = \{10,20,30,40,50\}$ and $A = \{30,50\}$.

If A' is the set with all the members of the universe which are not in A, then:

A' = ______ (copy "A' =" when you answer this.)

---

universal

$A' = \{10,20,40\}$

GROUP V

B (Write your answer, either A or B.)

A. There are two kinds of subsets. The first kind we shall consider is a proper subset.

Consider: $E = \{a,b,c,d\}$ $F = \{c,a\}$

To identify a set as a proper subset we must first see if it is a subset. Is $F \subset E$?

Then, if $F \neq E$, F is a proper subset of E.

F is a ______ subset of E because the following two conditions are true: F _?_ E F _?_ E

---

yes, proper, $F \subset E$, $F \neq E$

B. When these two conditions hold: Given set H, $J \subset H$
$J \neq H$

we call the subset, J, a proper subset of H.

(1) Tell which of the following are proper subsets:

Given set $B = \{l,m,n,o,p,q\}$

$A = \{l,m,n\}$ $C = \{p\}$ $D = \{l,m,n,o,p,q\}$ $E = \{4,p,q\}$

(2) What is the difference between a proper subset and an improper subset?

A, C are proper subsets

Both proper and improper subsets are subsets of a given set, but an improper subset is equal to the set itself and a proper subset is not equal to it.

GROUP VI.

B (Write your answer, either A or B.)

A. You know that $x > 5$ means x is greater than 5; and $x = 5$ means x equals 5.

Sometimes the two expressions are combined into one like this: $n \geq 5$. This means n is greater than or equal to 5.
Use symbols to write the following:
(a) The number, n, is larger than or equal to 9.
(b) The number, n, is larger than 9.
(c) y is larger than or equal to z.

(a) $n \geq 9$ (b) $n > 9$ (c) $y \geq z$

B. You know that $x > 5$ means x is greater than 5; and $x = 5$ means x equals 5.
Sometimes the two expressions are combined into one like this: $x \geq 5$
How would you combine the following:

(a) $n > 8$
$n = 8$

(b) $n > 12$
$n = 12$

(a) $n \geq 8$ (b) $n \geq 12$

GROUP VII.

A. (Write your answer, either A or B.)

A. The set of elements common to A and B is the set 12, and can be written: $A \cap B = \{12\}$.

(a) Using symbols write: The set of elements common to A and C is the set 15, 18, and 21.

(b) What symbol is used to mean the set of elements common to?

(a) $A \cap C = \{15,18,21\}$
(b) $\cap$

B. Suppose $U = \{3,6,9,12\}$ $A = \{3,6\}$ $B = \{6,12\}$
Notice that 6 is the only element common to both sets A and B.
This is the intersection of A and B.
If: $C = \{1,2,3,4,5\}$
$D = \{3,5,7\}$

___ and ___ are common to C and D and therefore form the set called the ______________ of C and D.

3, 5 intersection

GROUP IX.

B (Write your answer, either A or B.)

A. It is not always so convenient to write in words "is a subset of", so we've invented a symbol for that.

B is a subset of A, can be written: $B \subset A$

C is a subset of K, can be written: $G \subset K$

1. N is a subset of M, can be written: ________.
2. R is a subset of S, can be written: ________.

$N \subset M$ $R \subset S$

B. Instead of using the words "is a subset of", a more convenient way to express this is the symbol $\subset$. If B is a subset of A, we write this: $B \subset A$. This means that all the elements of B are in set A.

Suppose B is not a subset of A. We would write it like this: $B \not\subset A$. In words, how is the symbol $\not\subset$ read?

---

is not a subset of

GROUP X.

A (Write your answer, either A or B.)

A. An expression written in set-builder notation notation such as $A = \{n | n \in \text{whole numbers}\}$ would be read as: A is the set of numbers, n, such that the number is a whole number.

Similarly, we use these inequalities in set notation in the following way: $\{n | n \geq 15\}$, which reads: the set of numbers, n, such that the number is ________ than or ________ to 15.

---

greater (larger)   equal

B. $\{n | n \geq 15\}$ would read: the set of numbers, n, such that the number is larger than or equal to fifteen. How would you write in symbols: the set of numbers such that the number is greater than or equal to four?

$\{n | n \geq 4\}$

THE TRANSFER TEST

GROUP A

A tenth grade homeroom has 11 boys and 14 girls. For his convenience the homeroom teacher, Mr. Weissnichts, assigns each pupil a number by going in alphabetical order through the boys and then in alphabetical order through the girls. Thus Aaron Abrams gets no. 1 and Zeke Zilch, the last boy, gets no. 11, Betty Brown, the first girl, gets no. 12 and Susie Smith, the last girl, no. 25. Let the universal set (U) be the set of pupils in Mr. Weissnichts' homeroom.
Thus we can write U = $\{1,2,3,4.....25\}$

Write the symbols for

1. set B, where B is the set of boys.

2. set G, where G is the set of girls.

3. set T, where T is the set of girls whose last name begins with T.

GROUP B

Let A be the set of pupils in Mr. Weissnichts' homeroom who are taking algebra. It happens that these are the first five boys $\{1,2,3,4,5\}$ and the last five girls $\{21,22,23,24,25\}$.

1. Write a set description for set A.

2. Is each of the following true or false?

   (a) 12 is a member of A
   (b) 4 is a member of A
   (c) 25 is a member of A
   (d) A is a subset of B (set of boys)
   (e) A is a subset of G (set of girls)
   (f) G is a subset of B

GROUP C

In Mr. Weissnichts' homeroom suppose that every other boy, starting with no. 1, and every other girl, starting with no. 13, are the pupils studying French. Let F be the set of pupils studying French.

1. Write a set description for F.

2. List the members of A intersection F, where A is the pupils taking algebra. (See Group B for members of set A.)

GROUP D

In Mr. Weissnichts' homeroom, let S be the set of pupils who take sewing. Every girl decided to take sewing and no boys decided to take sewing. Are the following true or false?

1. S is a subset of G (set of Girls)

2. G is a subset of S

3. S equals G

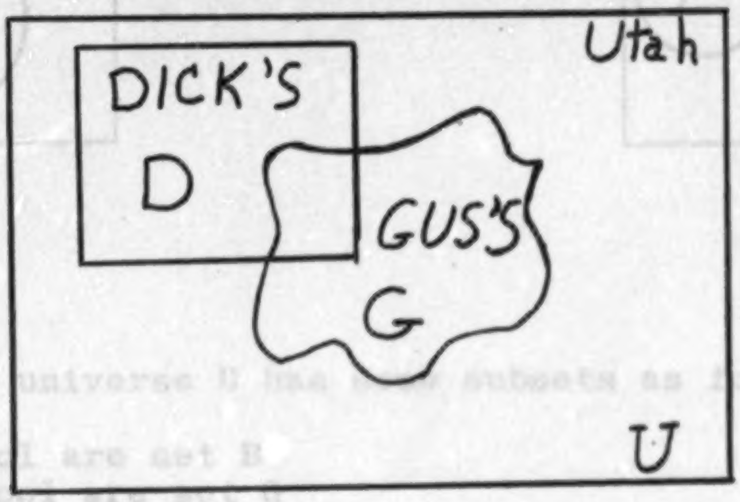
4. 11 is a member of S

5. 21 is not a member of S

6. S union B (boys) equals the Universe (all students in class)

GROUP E

Two miners, Klondike Dick and Golddust Gus, staked out their claims in Utah at different times. The next day they discovered their claims looked like this:



Let D stand for Dick's claim.
Let G stand for Gus's claim.
Let U stand for Utah.

1. If they decide to become partners, shade the area they would both own.

2. If they decide to fight because the claims overlap, shade in the area they will be fighting about.

3. Shade in Gus's claim if he wins the fight over the disputed area (the area they both claim).

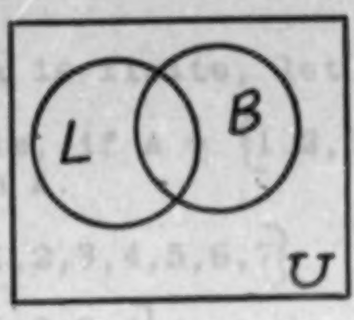
4. Shade in Dick's claim if he wins the fight over the disputed area.

5. Suppose the Marshall stops them from fighting and takes the area. Shade in the area that would belong to Dick's claim.

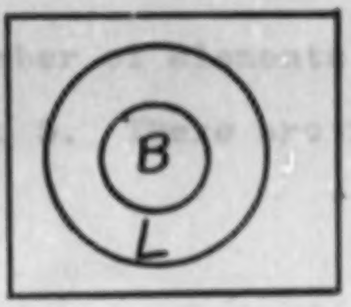
GROUP F

In a ninth grade homeroom there are 30 pupils. Let the thirty pupils be the universe (U). Seventeen of the pupils are boys. Let B equal the set of boys. Twelve pupils are studying Latin and four of the 12 are boys. Let L equal the set of pupils studying Latin. Are the following Venn diagrams true of false?

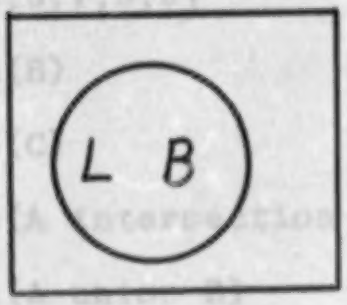
1.



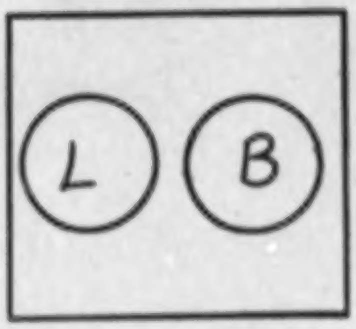
3.



2.



4.

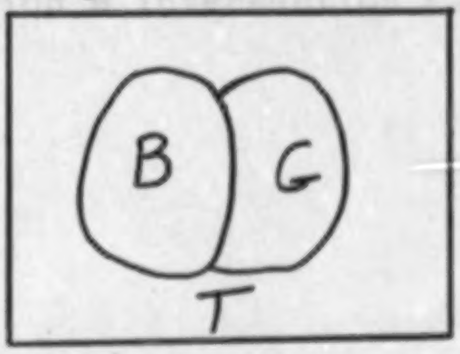


GROUP G

In a high school the universe U has some subsets as follows:

the boys in the school are set B
the girls in the school are set G
the teachers in the school are set T

A Venn diagram of the high school would like this:



1. Suppose set F is the football squad. Using the symbol Ⓕ, place it correctly on the Venn diagram of the high school. The size of the symbol Ⓕ is not important here - only where you place it.

2. Suppose set M is the marching band. Using the symbol Ⓜ, place it correctly on the Venn diagram of the high school (don't forget that Betty Klang plays the cymbals and Tom Thomas plays the drums). The size of the symbol Ⓜ is not important here - only where you place it.

GROUP H

If a set A is finite, let $n(A)$ stand for the number of elements in A.

For example, if $A = \{1,2,3,4,5\}$ then $n(A)$ equals 5. There are five members in A.

Let $A = \{1,2,3,4,5,6,7\}$

Let $B = \{1,2,3,4\}$

Let $C = \{5,6,7,8,9\}$

1. find $n(B)$

2. find $n(C)$

3. find n(A intersection B)

4. find n(A union B)

GROUP I

Let $U = \{n \mid 1 \leq n \leq 10\}$

and $A = \{1,2,3,4\}$ $B = \{1,2,3,4,6,7\}$ $C = \{6,7,8,9,10\}$

1. Place the elements in the proper sets in the Venn diagram.

2. Find A intersection B.

3. Find A intersection B intersection C.

APPENDIX B

SAMPLES OF EXPERIMENTAL MATERIALS
USED IN EXPERIMENT II

SAMPLES OF THE EXPERIMENTAL MATERIALS
USED IN EXPERIMENT II

Program E_1

1. Animals which have backbones are classified as vertebrates. Birds have backbones and, therefore, are ________.

vertebrates

2. With the exception of mammals, birds are the only warm-blooded animals. The Prairie Falcon is a member of the bird family, and as such is a ________________ animal.

warm-blooded

3. Birds have well-developed vocal mechanisms. The singing of birds is made possible because of their well-developed ____________.

vocal mechanisms

4. The forelimbs (arms) of birds are unique since they have been modified into wings. In the development of the bird, the arms or forelimbs were gradually modified into ________.

wings

5. Birds also have airspaces in the larger bones of their body. These ______________ tend to aid the birds in flight by decreasing the body weight.

airspaces in the larger bones

6. One of the most distinctive features of this group is their body covering of feathers. While other animals with backbones may have a body covering of fur, scales, or hair, only the birds have a body-covering of ________.

feathers

7. What are six features or aspects of the birds?

1. vertebrates
2. warm-blooded
3. vocal mechanisms
4. wings
5. airspaces in the larger bones
6. feathers

Program E_2

1. Just as the distance between the tops of two adjacent waves at the seashore varies, so do the wave lengths of light. They vary from ten trillionths of an inch to many miles in length. Thus, it can be concluded that ______________ of light vary greatly.

wave lengths

2. Light is a form of radiant energy that travels in packets of energy called photons. When you lay in the sun, your body absorbs (1)________________ that travels in small bursts called (2)______________.

(1) radiant energy
(2) photons

3. Issac Newton, in 1666, passed a beam of sunlight through a glass prism and noted how it separated light into different colors. "Red" light consists of wave lengths about 30 millionths of an inch in length, while blue light consists of wave lengths about 18 millionths of an inch in length. As the wave length of light changes so does the ______________ of the light.

color

4. Another property that concerns us is the intensity of light. Light excites the sensation of sight. However, if the light is of very low ____________, the light will not ___________ ___________________ enough so that we can detect it.

intensity
excite the sensation of sight

5. Name six features or facts associated with light.

1. wave lengths
2. photons
3. radiant energy
4. color
5. intensity
6. excite the sensation of sight

Program E_3

1. The duckbilled platypus has a thick coat of fur and webbed toes. This ____________________ protects him from the weather and his _______________ help him to travel about.

thick coat of fur
webbed toes

2. The duckbilled platypus is a mammal but is unusual in that it lays eggs. This animal belongs to the general class of ______________ but is different in that it _______________.

mammals
lays eggs

3. The duckbilled platypus differs from other animals in that it has subcutaneous mammary glands (beneath the skin) and a reptilian skeleton. Ornithorhynchus paradoxus, a platypus, has _________________ (beneath the skin) and a ___________________ (like a snake).

subcutaneous mammary glands
reptilian skeleton

4. What are six features of the duckbilled platypus?

1. thick coat of fur
2. webbed toes
3. mammal
4. lays eggs
5. subcutaneous mammary glands
6. reptilian skeleton

Program E_4

1. Pelicans are a group of related birds with completely webbed feet and a distensible pouch which hangs from the lower bill. Pelicans have vertical nasal tubes and a long and hooked bill. As another characteristic, they have a four-chambered heart and subcutaneous air sacs (under the skin). The common pelican inhabiting the Atlantic coast has completely ____________ and a ____________ with which he scoops up fish. He also has ________________ and a ________________ which he uses to catch the fish. As do all birds, pelicans have a ________________ and not a two-chambered one. Unlike other birds, pelicans have ____________________ which prevent them from diving too deeply.

webbed feet
distensible pouch
vertical nasal tubes
long and hooked bill
four-chambered heart
subcutaneous air sacs

2. What are six features of pelicans?

1. webbed feet
2. distensible pouch
3. vertical nasal tubes
4. long and hooked bill
5. four-chambered heart
6. subcutaneous air sacs

Program E_5

1. While flowers differ in some details, they have many similar features. In most cases, the brightly-colored part of the flower is the petal. The color which attracts insects is contained in the ______________ of the flower.

petal

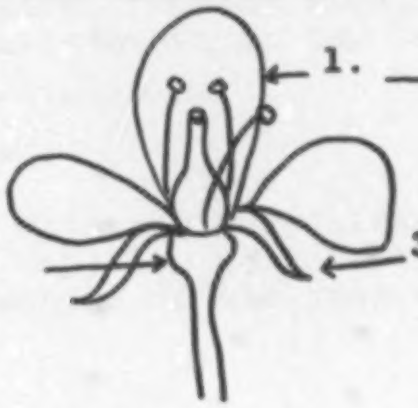
2. These brightly-colored parts are arranged on a cup-like receptacle. That is, the base of the flower is a __________________________.

cup-like receptacle

3. The leaf-like structures fastened to the base are called the sepal and may have at one time enclosed the flower. The green leaves enclosing the bud of a flower are the ______________ of the flower.

sepal

4. In this drawing the following parts of a flower can be identified:



1. petal
2. cup-like receptacl
3. sepal

5. Supporting the entire flower is the stem. The flower will droop if there is a lack of water in the _________.

stem

6. Looking at the 'insides' of the flower, you will notice small rod-shaped structures rising from the base of the flower. These structures are known as stamen. The small, rod-shaped structures are called ___________ and carry pollen.

stamen

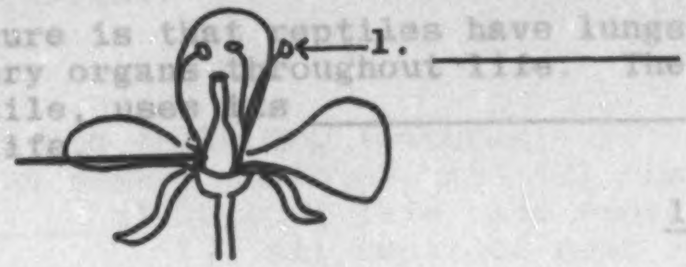
7. Inside the circle of these small rod-shaped structures is the pistil, whose function is to produce seeds. Among other parts, the ___________ helps with the reproduction process.

pistil

Program E_5 (cont.)

8. In this flower, the following parts marked by the arrow are:

2. ______



1. stamen
2. pistil

9. What are six parts of a flower?

1. petals
2. cup-like receptacle
3. sepal
4. stem
5. stamen
6. pistil

Program E_6

1. Reptiles are characterized by a dry horny body covering. Thus, the Desert Tortoise, a reptile, has this feature of a ________________.

dry horny body covering

2. Another feature is that reptiles have lungs which they use as respiratory organs throughout life. The Gila Monster, another reptile, uses its ______________________________ throughout life.

lungs as respiratory organs

3. The bodies of both the alligator and the desert tortoise are protected by a ______________. Reptiles have ______________ which are similar to the respiratory organs in man.

dry horny body covering
lungs as respiratory organs

4. Among the reptiles, reproduction is by internal fertilization. Among the reptiles known as the Horned Lizards, reproduction is by ________________.

internal fertilization

5. Reptiles share with the amphibians the handicap of being cold-blooded. Reptiles must restrict their activities to the warmer months of the year since they are __________.

cold-blooded

6. The alligator, being a reptile, reproduces by the process known as ______________. This reptile must also restrict its activities to the warmer months of the year because it is ________________.

internal fertilization
cold-blooded

7. For the level of development that they have achieved, the reptiles have a fairly large brain in relation to the rest of their body. The Horned Rattlesnake, a reptile, has a fairly ____________ in relation to the rest of its body.

large brain

8. Reptiles are characterized by having poor hearing. The American alligator, another reptile, has this feature of ________________.

poor hearing

Program E_6 (cont.)

9. The lizard has a fairly ____________ in relation to the rest of its body, even though the lizard's level of development is not high. This lizard has __________ __________ which is in marked contrast to its remarkable eyesight.

large brain
poor hearing

10. Reptiles have the following features: (1) a ____________ as seen in the desert tortoise, and (2) they use their ______________ throughout life, and reproduction is by ______________. All reptiles must restrict their activities to the warmer climates since they are ___________. With respect to the rest of their body, reptiles have fairly ________________ but they have notoriously ________________.

(1) dry horny covering
(2) lungs as respiratory organs
internal fertilization

cold-blooded
large brain
poor hearing

11. Name six features of reptiles.

1. dry horny body covering
2. lungs as respiratory organs
3. internal fertilization
4. cold-blooded
5. large brain
6. poor hearing

SAMPLE OF DIFFICULTY RATING SCALE USED IN EXPERIMENT II

	Very hard	Hard	Okay	Easy	Very easy
1. Birds					
2. Light					
3. Duckbilled Platypus					
4. Pelicans					
5. Flowers					
6. Reptiles					

APPENDIX C

SAMPLES OF EXPERIMENTAL MATERIALS USED IN EXPERIMENT III

1

TWO CHARACTERISTICS OF THE CLASS CEPHALOPODA ARE:

1. THEY HAVE ARM SUCKERS
2. THEY HAVE A STEERING FIN

THE SQUID BELONGS TO THE CLASS CEPHALOPODA,

THEREFORE, THE SQUID HAS ________ ________

AND ________ ________.

1A

ARM SUCKERS

STEERING FIN

2

LIST TWO CHARACTERISTICS OF THE CLASS CEPHALOPODA.

(ANY ORDER IS CORRECT)

2A

CUPLIKE SUCKERS

TRIANGULAR FIN

3

TWO ADDITIONAL CHARACTERISTICS OF THE CLASS CEPHALOPODA ARE:

3. THEY HAVE A CENTRAL MOUTH
4. THEY ARE SIPHON-POWERED (THEY MOVE BY FORCING WATER BACKWARD TO PROPEL THEM FORWARD).

THE NAUTILUS BELONGS TO THE CLASS CEPHALOPODA,

THEREFORE, THE NAUTILUS HAS A ________ ________

AND IS ________ __________.

3A

CENTRAL MOUTH

SIPHON-POWERED

4

LIST FOUR CHARACTERISTICS OF THE CLASS CEPHALOPODA.

(ANY ORDER IS CORRECT)

4A

ARM SUCKERS
STEERING FIN
CENTRAL MOUTH
SIPHON-POWERED

5

TWO ADDITIONAL CHARACTERISTICS OF THE CLASS CEPHALOPODA ARE:

5. THEY HAVE A LARGE HEAD

6. THEY HAVE MANY ARMS

THE OCTOPUS BELONGS TO THE CLASS CEPHALOPODA,

THEREFORE, THE OCTOPUS HAS A ______ ________

AND ________ __________.

5A

LARGE HEAD

MANY ARMS

6

LIST SIX CHARACTERISTICS OF THE CLASS CEPHALOPODA.

(ANY ORDER IS CORRECT)

7

SELECT FROM THE LIST BELOW THE TWO ANIMALS MOST LIKELY TO BELONG TO THE CLASS CEPHALOPODA ON THE BASIS OF THE CHARACTERISTICS GIVEN.

THE SCALLOP WHICH HAS MANY EYES.

THE TOOTH SHELL WHICH HAS A TUBULAR SHELL.

THE DEVILFISH WHICH HAS MANY ARMS.

THE SEA ARROW WHICH HAS A LARGE HEAD.

1. ____________

2. ____________

GENERAL BIOLOGY CLASSIFICATION TEST
FORM A

Name ______________________

I. List six characteristics of the Class Mammalia.

1. ________________ 4. ________________

2. ________________ 5. ________________

3. ________________ 6. ________________

Given the following characteristics, select the two animals from the list below which most likely belong to the Class Mammalia.

The kangaroo which has body hair.

The bat which has four limbs.

The turtle which has a retractable head.

The whale shark which has no lungs.

1. ________________

2. ________________

II. List six characteristics of the Class Reptilia.

1. ________________ 4. ________________

2. ________________ 5. ________________

3. ________________ 6. ________________

Given the following characteristics, select the two animals from the list below which most likely belong to the Class Reptilia.

The chameleon which is cold blooded.

The newt which has four legs.

The caecilian which has two eyes.

The sphenodon which has horny scales.

1. ________________

2. ________________

APPENDIX D

SAMPLES OF EXPERIMENTAL MATERIALS

USED IN EXPERIMENT IV *

***These materials were prepared by Mr. Edward Rosenstock, Research Associate, Susquehanna Valley Program, Bucknell University.**

MATURATION AND GROWTH

L P Name ____________________

1. Maturation refers to an individual's process of physical growth. A baby cannot walk during the first year of infancy because he does not have the strength and coordination necessary to walk. The baby must wait until the process of physical growth, called ____________________, gives him this capacity.

2. The process of physical growth, called maturation, brings about certain behavioral changes in an individual. The baby's behavioral change from not walking to walking can be attributed to maturation, the ______________ of physical ______________.

+3. If a behavioral change in an individual is observed and no previous training occurred, we say the change is due chiefly to ____________ which is a continuing ____________ of physical ____________.

4. Behavioral changes brought about by maturation are relatively unrelated to training or practice. Jim walked at the age of 13 months, while Ron, his twin brother, was prevented from walking until 16 months. Ron then learned to walk more quickly than his brother had. Since Ron was not allowed to walk until 16 months, we could say this behavioral __________ was due to maturation and not training or experience.

5. We use the word maturation to account for Ron's learning to walk as quickly as his brother because he (Ron) had no previous ______________ with walking.

+6. It can be said, then, that maturation is a process in growth which brings about changes in ______________ relatively unrelated to previous ______________.

*7. Define maturation:

*8. Maturation refers to an individual's process of ____________.

* 9. Maturation brings about behavioral ______________ relatively unrelated to previous ______________.

*10. Would the following behavior be attributed to maturation alone, experience alone, or both?
An American learning to speak French at age 20?

____

11. The word "Readiness" implies that an individual has the potential to perform certain tasks, mental or physical. A child cannot read before he is ____________ to read.

12. If a child is ready to perform a task, he has the potential for performance. In other words, readiness implies ____________ to perform certain tasks.

+13. A child who has had experiences which relate positively to his ability to walk and who has reached the period of maturation which enables him to do so, is ____________ to perform this particular task, and has the ______________ to do so.

14. A newborn child is unable to read because his neuromuscular growth has not reached a certain advanced stage of development. Just as a newborn child is not mature enough to walk, he is not ____________ enough to read.

15. Assume that a child has reached the stage of growth in which his neuromuscular development is sufficient to enable him to read but he never is given any experience with reading. The child ______________ (will, will never) learn to read.

+16. Attempts to teach a five-day old child to read are futile because the child is not ________________ enough to perform this task. In addition, the child must have the proper kind of ________________.

*17. Define readiness:

*18. Readiness includes two important requirements, both ________________ and ________________.

*19. A father was unsuccessful in teaching his four-year old son to ride a bicycle. Although they practiced often, the boy made no progress. Why do you think the boy has failed?

____

20. Formative periods are those times in an individual's life in which he has the first opportunity to engage in an activity. Usually, the first opportunity a child has to engage in physical skills is from age 1 to age 4. This period is called a ______________ period for physical skills.

21. The main characteristic of formative periods is that they are the ______________ time a person has the opportunity to engage in a particular activity.

+22. Frequently, the development of attitudes regarding one's intellectual abilities develops during the first year of school. For many, the first year of school, then, is the ______________ period for developing such intellectual abilities because it is the ______________ opportunity to engage in such activities.

23. Success or failure in performing tasks during a formative period preconditions later performance in these tasks. A child whose first attempts at reading are very unsuccessful __________ (may or may not) have later problems in the performance of this task.

24. Inadequate development during a formative period may not adversely affect an individual's performance. Jim's first attempts at learning to add were very unsuccessful. We ______________ (may or may not) predict that Jim will not learn to add.

+25. The formative period for forming social relationships occurs approximately between ages 3-7. A child who has not learned to get along with playmates by age 10 ______________ (may or may not) do so later.

*26. Define formative period:

*27. Earlier we said that the formative period for physical skills occurs at approximately ages 1-4. Difficulty learning physical skills during this time ______________ (might, might not) mean later difficulty.

*28. Formative periods are important because they are the ______________ opportunities to learn an activity.

*29. John learned to creep at 6 months and continued creeping at 8 months. John's formative period for creeping occurred at ________ (6, 8) months.

30. Developmental tasks are roles which the individual's society expects him to perform. Our society expects teenage boys and girls to date. Dating is a ______________ task in our culture.

31. Developmental tasks are performed at certain stages of an individual's growth. For example, our society expects dating to begin between ages 12 and 16. The developmental task of dating is a ____________ our culture expects an individual to perform.

+32. Following high school, a young man is expected by his society to further his education or to obtain a job. These activities could be called ____________ ____________ because they are ____________ his society expects him to perform.

33. Some developmental tasks arise mainly from physical maturation. Walking is a task which occurs mainly from physical maturation and it is expected at a certain ____________ of our physical growth.

34. In addition to physical maturation, social pressure can create developmental tasks, but interest in the opposite sex during adolescence is brought on mainly by ____________ maturation. Acceptable behavior in the presence of the opposite sex is defined mostly by social pressure.

+35. Learning to read is a developmental task arising from both social pressure and ______________ ______________ and occurs at a certain ____________ in our development.

36. In addition to physical maturation, ____________ pressure can bring about developmental tasks.

37. Failure during formative years does not necessarily presuppose later failure. However, the learning of developmental tasks is nearly obligatory for later success or failure. The developmental task of adapting tool skills occurs between 5 and 9 years of age. An individual who fails at this task is most likely to ____________ (succeed, fail) at this task later in his life.

+38. Getting a job or going to college is a developmental task arising from ______________ (social pressure, physical maturation). Failure in learning a developmental task is usually __________ (more, less) serious than failing during a formative period.

MATURATION AND GROWTH

L

Name ____________________

1. Maturation refers to an individual's process of physical growth. A baby cannot walk during the first year of infancy because he does not have the strength and coordination necessary to walk. The baby must wait until the process of physical growth, called ____________________, gives him this capacity.

2. The process of physical growth, called maturation, brings about certain behavioral changes in an individual. The baby's behavioral change from not walking to walking can be attributed to maturation, the ______________ of physical ________________.

3. Behavioral changes brought about by maturation are relatively unrelated to training or practice. Jim walked at the age of 13 months, while Ron, his twin brother, was prevented from walking until 16 months. Ron then learned to walk more quickly than his brother had. Since Ron was not allowed to walk until 16 months, we could say this behavioral ______________ was due to maturation and not training or experience.

4. We use the word maturation to account for Ron's learning to walk as quickly as his brother because he (Ron) had no previous ____________________ with walking.

*5. Define maturation:

*6. Maturation refers to an individual's process of ________________.

*7. Maturation brings about behavioral ______________ relatively unrelated to previous ______________.

*8. Would the following behavior be attributed to maturation alone, experience alone, or both?
An American learning to speak French at age 20?
____

9. The word "Readiness" implies that an individual has the potential to perform certain tasks, mental or physical. A child cannot read before he is _____________ to read.

10. If a child is ready to perform a task, he has the potential for performance. In other words, readiness implies ______________ to perform certain tasks.

11. A newborn child is unable to read beacuse his neuromuscular growth has not reached a certain advanced stage of development. Just as a newborn child is not mature enough to walk, he is not __________ enough to read.

12. Assume that a child has reached the stage of growth in which his neuromuscular development is sufficient to enable him to read but he never is given any experience with reading. The child ______________ (will, will never) learn to read.

*13. Define readiness:

*14. Readiness includes two important requirements, both ______________ and ______________.

*15. A father was unsuccessful in teaching his four-year old son to ride a bicycle. Although they practiced often, the boy made no progress. Why do you think the boy has failed?

____

16. Formative periods are those times in an individual's life in which he has the first opportunity to engage in an activity. Usually, the first opportunity a child has to engage in physical skills is from age 1 to age 4. This period is called a ______________ period for physical skills.

17. The main characteristic of formative periods is that they are the ______________ time a person has the opportunity to engage in a particular activity.

18. Success or failure in performing tasks during a formative period preconditions later performance in these tasks. A child whose first attempts at reading are very unsuccessful __________ (may, may not) have later problems in the performance of this task.

S

MATURATION AND GROWTH

Name ______________________________

1. Maturation refers to an individual's process of physical growth which brings about behavioral changes. When a child undergoes the behavioral change of walking, we know the process of physical ______________ called ________________ has given him the capability.

2. Behavioral changes brought about by maturation are relatively unrelated to training or practice. Jim walked at the age of 13 months, while Ron, his twin brother, was prevented from walking until 16 months. Ron then learned to walk more quickly than his brother had. Since Ron was not allowed to walk until 16 months, we can say this ________________ change was due to maturation and unrelated to previous ________________ or practice.

*3. Define maturation:

*4. Maturation refers to an individual's process of ____________.

*5. Maturation brings about behavioral ______________ relatively unrelated to previous ______________.

*6. Would the following behavior be attributed to maturation alone, experience alone, or both?
An American learning to speak French at age 20? ________________

7. The word readiness implies that an individual has the potential to perform certain tasks, mental or physical. A child cannot read before he is ____________ to read, that is, before he has the ______________ to perform the task of reading.

8. A newborn child is unable to read because he lacks experience in reading and because his neuromuscular movement has not reached a certain advanced stage of development. Just as a newborn child is not mature enough to walk, he is not ______________ enough to read. If he never receives any experience with reading after he matures, he ______________ (will, will not) learn to read.

S

*9. Define readiness:

*10. Readiness includes two important requirements, both ____________________ and ____________________.

*11. A father was unsuccessful in teaching his four-year old son to ride a bicycle. Although they practiced often, the boy made no progress. Why do you think the boy has failed?

____

12. Formative periods are those times in an individual's life in which he has the first opportunity to engage in an activity. The first opportunity a child has to engage in physical skills is from age 1 to 4. This __________ opportunity to learn physical skills is called a ______________ ______________.

13. Success or failure during a formative period may precondition later performance in these tasks. Jim, whose first attempts at reading are very unsuccessful, ______________ (may, may not) have later problems reading. However, this early setback does not necessarily mean permanent damage. We ______________ (may, may not) predict that Jim will not learn to read.

*14. Define formative period:

*15. Earlier we said that the formative period for physical skills occurs at approximately ages 1-4. Difficulty learning physical skills during this time ________________ (might, might not) mean later difficulty.

*16. Formative periods are important because they are the ____________ opportunities to learn an activity.

*17. John learned to creep at 6 months and continued creeping at 8 months. John's formative period for creeping occurred at ___________ (6, 8) months.

SP

MATURATION AND GROWTH

Name ____________________

1. Maturation refers to an individual's process of physical growth which brings about behavioral changes. When a child undergoes the behavioral change of walking, we know the process of physical ____________ called ____________ has given him the capability.

+2. If a behavioral change in an individual is observed and no previous training occurred, we say the change is due chiefly to ____________ which is a continuing ____________ of physical ____________.

3. Behavioral changes brought about by maturation are relatively unrelated to training or practice. Jim walked at the age of 13 months, while Ron, his twin brother, was prevented from walking until 16 months. Ron then learned to walk more quickly than his brother had. Since Ron was not allowed to talk until 16 months, we can say this ____________ change was due to maturation and unrelated to previous ____________ or practice.

+4. It can be said, then, that maturation is a process in growth which brings about changes in ____________ relatively unrelated to previous ____________.

*5. Define maturation:

*6. Maturation refers to an individual's process of ____________.

*7. Maturation brings about behavioral ____________ relatively unrelated to previous ____________.

*8. Would the following behavior be attributed to maturation alone, experience alone, or both?
An American learning to speak French at age 20?

____

9. The word readiness implies that an individual has the potential to perform certain tasks, mental or physical. A child cannot read before he is ____________ to read, that is, before he has the ____________ to perform the task of reading.

+10. A child who has had experiences which relate positively to his ability to walk and who has reached the period of maturation which enables him to do so, is ____________ to perform this particular task and has the ________________ to do so.

11. A newborn child is unable to read because he lacks experience in reading and because his neuromuscular movement has not reached a certain advanced stage of development. Just as a newborn child is not mature enough to walk, he is not ______________ enough to read. If he never receives any experience with reading after he matures, he ______________ (will, will not) learn to read.

+12. Attempts to teach a five-day old child to read are futile because the child is not ______________ enough to perform this task. In addition, the child must have the proper kind of ________________.

*13. Define readiness:

*14. Readiness includes two important requirements, both ________________ and ________________.

*15. A father was unsuccessful in teaching his four-year old son to ride a bicycle. Although they practiced often, the boy made no progress. Why do you think the boy has failed?

____

16. Formative periods are those times in an individual's life in which he has the first opportunity to engage in an activity. The first opportunity a child has to engage in physical skills is from age 1 to 4. This ____________ opportunity to learn physical skills is called a ________________ ________________.

+17. Frequently, the development of attitudes regarding one's intellectual abilities develops during the first year of school. For many, the first year of school, then, is the ________________ period for developing such intellectual abilities because it is the ____________ opportunity to engage in such activities.

18. Success or failure during a formative period may precondition later performance in these tasks. Jim, whose first attempts at reading are very unsuccessful, ______________ (may, may not) have later problems reading. However, this early setback does not necessarily mean permanent damage. We ______________ (may, may not) predict that Jim will not learn to read.

Name________________________

For the past week you have been working with some new concepts. We would like you to tell us whether you thought the concepts were easy or difficult.

For example, suppose the concept was "Growth" - if you thought "Growth" was a very difficult concept you would check it like this:

____ very easy ____ easy ____ ok ____ difficult __✓__ very difficul

Please check the appropriate category for each of the following concepts.

* * * * * *

MATURATION

____ very easy ____ easy ____ ok ____ difficult ____ very difficult

READINESS

____ very easy ____ easy ____ ok ____ difficult ____ very difficult

FORMATIVE PERIOD

____ very easy ____ easy ____ ok ____ difficult ____ very difficult

DEVELOPMENTAL TASKS

____ very easy ____ easy ____ ok ____ difficult ____ very difficult

NORMAL DISTRIBUTION

____ very easy ____ easy ____ ok ____ difficult ____ very difficult

SOMATOTYPES

____ very easy ____ easy ____ ok ____ difficult ____ very difficult

MATURATION AND GROWTH

Post-Test

Name ____________________

Define briefly:

1. **Maturation:**

2. **Readiness:**

3. **Formative period:**

4. **Developmental tasks:**

5. **Normal distribution:**

6. The best-known theory categorizing individuals according to physical size was devised by ____________________ (man's name).

7. A theory classifying individuals by body size or physique, is referred to as a theory of __________________________.

8. Match the following:

_____ Athletic, rugged type

_____ Small bones, skinny type

_____ Heavy, flabby type

_____ 1 - 7 - 1

A. Ectomorph

B. Endomorph

C. Mesomorph

. The gland which most influences the physical growth of an individual is the ___________________________.

. Match the following:

_____ Giantism

_____ Acromegaly

_____ Dwarfism

A. Insufficient secretion of the growth hormone after the growing years.

B. Excessive secretion of the growth hormone during the growing years.

C. Excessive secretion of the growth hormone after the growing years.

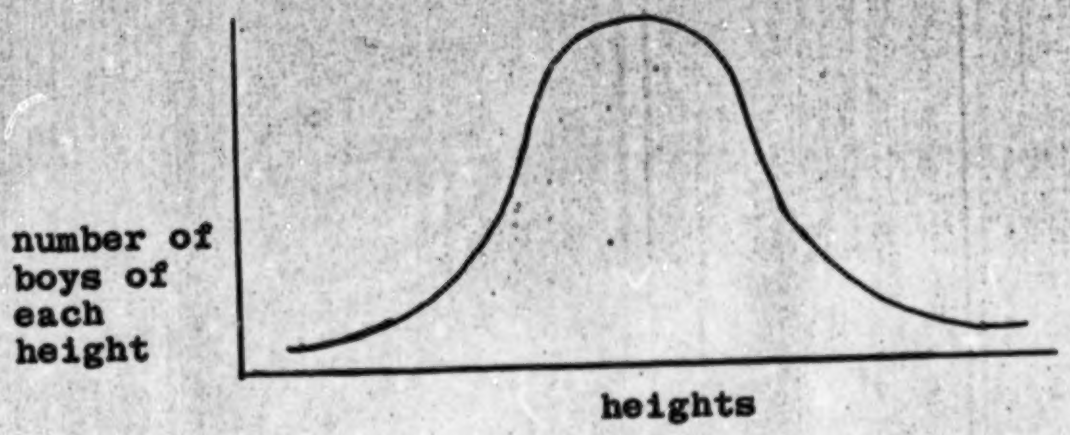
D. Insufficient secretion of the growth hormone during the growing years.

. Which is more nearly adult-like at birth?

______ The body or the head?

______ The arms or legs?

______ Height or weight?



The graph above illustrates the distribution of heights of 14-year old boys. This curve is called a ______________ ____________________ curve.

. Three problems facing adolescents are:

1. ____
2. ____
3. ____